

1 Title of the invention: Method and apparatus for
2 sampling fluids from a wellbore.

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4 Background to the invention:

5 This invention relates to a method and apparatus for
6 sampling fluids from a wellbore, and in particular to a
7 method and apparatus used to recover a quantity of
8 production fluids such as produced oil, gas and/or
9 water from the wellhead of an underwater well.

10

11 Wells for hydrocarbons and other valuable fluids are
12 normally drilled in a cluster with a number of
13 wellbores having their surface wellheads grouped
14 together. The wellbore may diverge away from each
15 other the deeper they become. The wellheads in a group
16 of wells are typically connected to a manifold or other
17 subsea structure via conduits, and the hydrocarbons
18 recovered from each individual well are conveyed along
19 the conduits to the manifold where they usually co-
20 mingle before flowing along a single main pipeline to
21 the production platform. The quality and quantity of
22 the fluids produced from each well may vary; for
23 example, one wellbore may produce production fluids
24 that are rich in crude oil and relatively free from

1 produced water and corrosive gasses such as H₂S, whereas
2 a neighbouring well drilled to a different depth in the
3 same formation may produce more water, or may have a
4 high content of noxious and corrosive gasses; such a
5 well would be less economically productive and may have
6 higher maintenance costs. Furthermore, different wells
7 tied back to the same manifold may be owned and/or
8 operated by different operators. It is therefore
9 useful to know the quantity and quality of wellbore
10 fluids that are produced from each respective wellbore
11 before they are mixed in the manifold or main pipeline
12 leading from the manifold to the production platform,
13 so that the relative benefits and liabilities of the
14 respective wells can be calculated.

15

16 Traditionally this has been done by sampling the fluids
17 produced at each respective wellbore by providing
18 separate sampling conduits or lines that run parallel
19 to (and usually along the outside of) the conduits
20 between the respective wellbores and the manifold, and
21 from there along the main pipeline back to the
22 production platform, where they can be analysed and
23 graded. Separate sampling lines are of course needed
24 for each wellbore, and this causes several problems in
25 that the additional small bore lines often become
26 blocked by viscous fluids and cuttings, or damaged by
27 corrosive agents like H₂S, and to address this several
28 lines are normally installed for each wellhead all the
29 way back to the platform, so that backup lines can be
30 brought into operation if the main sampling line for a
31 particular wellhead fails or becomes blocked. This is
32 very expensive and the infrastructure of the extra

1 lines needs to be installed at the beginning of the
2 life of a well, but is seen as the only solution to the
3 problems of being able to sample continuously
4 throughout the life of the well.

5

6 Summary of the Invention:

7

8 According to the present invention there is provided a
9 method for sampling a fluid from a wellbore, the method
10 comprising

11 a vehicle having a drive means for moving the
12 vehicle, a collecting device for collecting a sample of
13 the fluid and a storage facility for the collected
14 fluid;

15 using the collecting device to recover a sample of
16 the fluid to the vehicle's storage facility at a first
17 location on a subsea structure;

18 storing the sample in the storage facility of the
19 vehicle; and

20 carrying the sample in the vehicle's storage
21 facility to a second location.

22

23 The present invention also provides a sampling
24 device for collecting samples of fluid produced from a
25 subsea wellbore, the sampling device having;

26 a drive means for moving the sampling device, a
27 collection device for collecting a sample of fluid and
28 a storage container for holding the collected fluid.

2

30 The first location is typically a wellhead but can be
31 other positions of a well such as a wellbore, pipeline
32 from the wellhead, side-track manifold, or main

4

1 pipeline, storage tank or gravity base structure. The
2 first position typically has a collection port to mate
3 with the collection apparatus. The second position can
4 be onshore, underwater or on a platform or ship such as
5 a remotely operated vehicle or "ROV".

6

7 Preferably the vehicle is an ROV. Preferably the
8 storage tank and collection device are housed on a
9 frame or skid attached to the ROV. Typically the
10 collecting device comprises at least one sampling
11 bottle, but two or more can be provided.

12

13 Typically the vehicle is adapted to interface with the
14 wellhead at the first position, and can be provided
15 with a collecting and sampling probe for insertion into
16 e.g. an aperture on the wellhead. The probe can be
17 connected to the storage tanks or bottles etc by means
18 of conduits. Typically production fluids are extracted
19 via the male/female connection between the probe and
20 the aperture. The collecting device can be arranged to
21 collect and discard a portion of the fluids being
22 sampled, and typically recovers an initial sample of
23 fluid from the collection port of the wellhead to a
24 first sampling bottle. This is done because the fluid
25 lying in the collection port of the wellhead may be
26 static and may not represent a true sample of the fluid
27 flowing through the wellhead. Therefore, the first
28 sample of fluid from the collection port of the
29 wellhead is drawn off to a first sampling bottle and
30 can be kept separate from later samples. Any number of
31 later samples e.g. 3-10 can be taken from the fluid
32 flowing through the wellhead, depending on the number

1 of sampling bottles or partitions in the collection
2 tank that are available. Typically a waste tank is
3 provided at the second position into which the initial
4 samples of static fluid can be discarded.

5

6 Typically the vehicle has an array of valves which can
7 be activated independently of each other. Typically
8 different configurations of the valves will direct
9 liquid into each sampling bottle as required.

10 Typically the sampling bottles each contain a piston.
11 Normally a pressure gauge is connected to each sampling
12 bottle. Normally a piston indicator is provided so
13 the position of the piston can be determined from a
14 remote position outside the bottle. Typically the
15 piston indicator moves with the piston, but it may be
16 an electronic indicator that is monitored elsewhere on
17 the ROV or remote from it. Typically the piston
18 indicator is a rod which extends from the piston
19 outside the bottle. Typically the sampling bottles are
20 connected to the male connector via a hose of e.g.
21 1/4" diameter. The sampling bottles, valves and hose
22 are typically designed to operate in pressures of up to
23 230 barg and at temperatures of -50 to 130°C.

24

25 During transportation of the ROV prior to use, the
26 sampling apparatus is typically filled with a liquid.
27 Preferably the liquid is bio-degradable. Typically the
28 liquid is a mixture of water and glycol.

29

30 Typically the liquid is contained in the sampling
31 bottles when the vehicle dives. Typically the liquid
32 is expelled from a second end of the sampling apparatus

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1 as fluid is recovered from the wellhead. Preferably a
2 control means such as a throttle is provided on the
3 second end of the sampling apparatus to control the
4 rate of expulsion of the liquid. This typically
5 controls the rate of introduction of the fluid from the
6 wellhead into the first end of the sampling apparatus,
7 typically via the piston.

8

9 When production fluids have been extracted from the
10 first wellhead the vehicle typically disengages the
11 probe from the collection port on the wellhead and
12 moves (in ROV terminology it "flies") to the second
13 position. The second position can typically be an
14 offshore platform, a ship or an inshore facility. The
15 vehicle typically docks at the second position where
16 the sample(s) collected may be removed by e.g. removing
17 the sampling bottles and replacing them with empty
18 bottles. Typically only the second and subsequent
19 sampling bottles are replaced. Typically the fluid(s)
20 contained in the second or further sampling bottle is
21 analysed for fluid chemistry.

22

23 In several important embodiments of the invention the
24 collection device has several separate containers such
25 as bottles for collecting samples and the vehicle flies
26 between adjacent wellheads to collect samples from each
27 of them before returning to the ship or platform etc
28 for analysis of the samples. In this embodiment the
29 vehicle can collect different samples from adjacent
30 wellheads on a single trip.

31

1 While the ROV can be typically tied back to a ship or
2 platform by a conventional umbilical the vehicle need
3 not be a conventional ROV.

4

5 Typically the fluids contained in the first sampling
6 bottle will be released into the waste tank. Normally
7 this operation is performed at the second position.

8 Typically a particular combination of open and closed
9 valves can be used to direct fluids from any sampling
10 bottle to the waste tank.

11

12 The pipework is typically vented before the sampling
13 bottles are removed. This typically allows the
14 pressure in the pipework to be equilibrate with ambient
15 pressure and so ease the removal of the sampling
16 bottles from the vehicle. Typically a particular
17 configuration of the valves can be used to vent the
18 pipework. After the pipework has been vented the
19 sampling bottle(s) may be removed.

20

21 A new bottle is typically attached to the sampling
22 apparatus. Typically the sampling apparatus is flushed
23 with de-mineralised water to prevent
24 cross-contamination between samples. Typically the
25 sampling apparatus is purged with nitrogen prior to a
26 subsequent sampling run in order to remove air from the
27 pipework. Typically the sampling apparatus will be
28 tested for leaks whenever a sampling bottle has been
29 replaced.

30

31 Typically the vehicle (or at least the collection
32 device) will undergo a hydrotest before a second

1 operation. In the hydrotest the sampling bottles are
2 filled with de-mineralised water and pressurised up to
3 230 barg. If no leaks or change in pressure are
4 observed after a period in the order of 30 minutes the
5 vehicle is typically subjected to a gas test. During
6 the gas test, the vehicle (or at least the collection
7 device) is typically submerged in a water bath and is
8 flushed with Nitrogen gas through the probe to subject
9 the sampling apparatus to a pressure of up to 125 barg.
10 Any leaks would clearly be observed in the form of
11 bubbles escaping from the vehicle or collection device.

12

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15 Brief description of the drawings:

16 An embodiment of the invention will now be described by
17 way of example only with reference to the accompanying
18 drawings wherein;

19

20 Fig. 1 is a drawing of the sampling equipment;

21 Fig. 2a is a drawing of the sampling equipment
22 during the hydrotest;

23 Fig. 2b is a drawing of the sampling equipment
24 during the gas test;

25 Fig. 3 is a drawing of the sampling equipment
26 during the system purge;

27 Fig. 4a is a drawing of the sampling equipment
28 during transportation;

29 Fig. 4b is a drawing of the spare sampling bottle
30 during the transportation;

31 Fig. 5 is a drawing of the sampling equipment
32 prior to diving;

1 Figs. 6a to 6d are drawings of the sampling
2 equipment after docking at the panel;
3 Fig. 7 is a drawing of the sampling equipment at
4 the start of the sampling operation;
5 Fig. 8 is a drawing of the sampling equipment
6 during operation;
7 Fig. 9 is a drawing of the sampling equipment
8 after operation;
9 Fig. 10 is a drawing of the sampling equipment
10 during venting of the first sampling bottle;
11 Fig. 11. is a drawing of the sampling equipment
12 during purging of the sampling bottle with
13 water/glycol;
14 Fig. 12 is a drawing of the sampling equipment
15 prior to removal of the second sampling bottle;
16 Fig. 13 is a drawing of the sampling equipment
17 during removal of the second sampling bottle;
18 Fig. 14 is a drawing of the sampling equipment
19 during the flushing operation after insertion of a
20 fresh sampling bottle;
21 Fig. 15 is a drawing of the sampling equipment
22 during the during the purging operation after
23 insertion of a fresh sampling bottle;
24 Fig. 16 is a drawing of the sampling equipment
25 containing nitrogen;
26 Fig. 17 is a drawing of the sampling equipment
27 during the a leak test;
28 Fig. 18^{a-f are} is a general arrangement of a skid
29 containing the collecting device;
30 Fig. 19^{a-c} is a selection of view^s of the fig.18 skid
31 attached to an ROV;

10
a-f

1 Fig. 20 is a general arrangement showing the tools
2 attached to the ROV;
3 Fig. 21 is a drawing of the slops tank;
4 Fig. 22 is a drawing of a sampling bottle; and,
5 Fig. 23 is a drawing of a sampling skid control
6 console.

7
8

9 Detailed description of the drawings:

10 Referring now to the drawings, a collection device has
11 a first sampling bottle 10 connected between valves 11-
12 15 at the back end 27 of the bottle 10, and valves
13 17-20 at the front end 28. A second sampling bottle
14 110 is provided adjacent to the first 10 and is
15 connected between valves 111-115 at the back 127 of the
16 bottle 110 and valves 117-120 at a front opposite end
17 128. The valves 20, 120 are connected together by line
18 21. Pressure gauges 29, 129 (not shown in all Figs) are
19 provided for each sampling bottle 10, 110. A piston 16,
20 116 is provided inside each sampling bottle 10, 110.
21 Rods 39, 139 shown in Fig. 1 (but omitted from the
22 other figures for clarity) are attached to and move
23 with the pistons 16, 116. Each rod 39, 139 extends
24 from a respective piston 16, 116 through the back of a
25 respective bottle 28, 128 and so provides a means to
26 determine the position of the pistons inside the
27 sampling bottles. The rods can be sealed against the
28 ends of the bottles by o-rings etc (not shown).

29

30 In the drawings, a black-shaded valve indicates the
31 valve is closed, while an unshaded valve indicates the
32 valve is open. A valve shaded in grey indicates the

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1 valve is partially open. Valves 15, 115 remain
2 partially open throughout all operations and so will
3 not be referred to again.

4

5 The collection device is disposed in a frame or "skid"
6 60 that is connectable to the base of an underwater
7 vehicle or ROV 200. The ROV 200, as is conventional in
8 the art, typically has a motor (not shown) to move the
9 skid between first and second positions, and an
10 umbilical line connecting the ROV 200 to the operating
11 station. Typically the umbilical line comprises a
12 cable to power the hydraulic and electrical systems on
13 the ROV 200 and any other cables such as those
14 connected to onboard cameras.

15

16 A tool deployment unit (TDU) or XYZ tool position unit
17 80 is attached to the ROV 200 as shown in Fig. 19b.
18 The TDU 80 may comprise various tools like grabs,
19 cameras, docking probes and sockets to facilitate
20 docking of the ROV 200 with a manifold etc and can move
21 in a vertical, horizontal and fore-aft direction
22 relative to the ROV 200. The TDU chosen typically has
23 a low torque tool mounting bracket 65 fitted to the
24 lower carriage of the ROV 200 and two low torque tools
25 61, 62 fitted to the port side of the mounting bracket
26 65. The tools 61 and 62 are primarily for activating
27 isolation valves 31, 32 on the wellhead but can be used
28 for a wide variety of other operations. A grabber tool
29 63 is fitted to the starboard side of the mounting
30 bracket 65 and holds a single port male hot stab tool
31 33 fitted with a grabber handle to connect with the
32 grabber tool 63. The male hot stab tool 33 is

12

12

1 typically a standard sampling probe. The male hot
2 stab tool 33 is connected to the sampling equipment 100
3 by a hose 23 and two hydraulic lines. In practise it
4 may be necessary to alter the configuration of the low
5 torque tools 61, 62 and the grabber tool 63 so they
6 correspond with the receptacles and valves at the
7 particular wellhead where the ROV 200 will be docking.

8

9 The TDU has two docking probes 71, 72 which engage
10 receptacles (not shown) at the wellhead. These
11 stabilise the ROV 200 in position when it docks at a
12 wellhead. Alternatively, other docking means may be
13 used.

14

15 The sampling skid has a quick-connect fail-safe release
16 mechanism 66 in-line with the hoses 23 to the hot stab
17 tool 33 securely mounted in a suitable location on the
18 ROV 200 frame. The fail safe mechanism is activated
19 when either hydraulic or electric power is lost to the
20 sampling skid and ensures that no hydrocarbons are lost
21 and that the ROV 200 may be recovered. An accumulator
22 54 is provided, charged with hydraulic power to provide
23 power in sequence to various parts of the skid if
24 necessary. First, the accumulator provides power to
25 the torque tools 61, 62 to close off the isolation
26 valves 31, 32. Then, the fluid connection between the
27 male stab and the female connector is broken. Each of
28 the hoses connecting the male hot stab to the sampling
29 skid are then broken and the male hot stab is left
30 loosely attached to the female member. The hoses which
31 connect the male hot-stab to the skid are self-sealing
32 and so do not pollute the environment when

13

1 disconnected. A separate accumulator on the TDU (not
2 shown) provides power for the ROV 200 to disengage from
3 the receptacles. The ROV 200 is then recovered for
4 example by towing in, repaired and re-deployed.

5

6 A camera pan unit 68 is provided on the mounting
7 bracket 65 of the TDU positioned to allow the camera to
8 view the low torque tools 61, 62 and the hot stab tool
9 33. Other tooling cameras (not shown) are provided (i)
10 mounted to the camera pan unit for vertical alignment
11 of the low torque tools 61, 62 and hot-stab tool 33
12 with their interfaces and to monitor torque tool turns,
13 (ii) mounted to the TDU for horizontal alignment of the
14 low torque tools 61, 62 and the hot-stab tool 33 with
15 their interfaces and to monitor torque tool turns,
16 (iii) positioned to view the pressure gauge 29 and
17 indicator rod 39 on the first sampling bottle 10, (iv)
18 positioned to view the pressure gauge 129 and indicator
19 rod 139 on the second sample bottle 110, (v) positioned
20 to view the status of actuated valves 14, 114, 20, 120,
21 122. Instead of or in addition to cameras to view the
22 rods and tools directly the condition and positions of
23 the dials and tools can optionally be reported
24 electronically. The monitoring apparatus can be
25 adapted to indicate the characteristics of the sampled
26 fluid on either a continuous or intermittent basis.

27

28 Figs. 18a to Figs. 18f show the arrangement of the
29 parts which make up the skid. The sampling apparatus
30 100 is mounted onto a skid frame 60. Buoyancy members
31 92 are attached to a buoyancy frame 91 to provide
32 stability to the ROV 200 during operation underwater.

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1
2 The sampling bottles 10, 110 are connected by a
3 sampling line which comprises a series of valves. A
4 hydraulic supply 52 is provided at the centre of the
5 skid frame 60 to provide a means to actuate the
6 hydraulic valves via a hydraulic circuit. Two
7 compensators 53 are provided to hold the pressure of
8 the oil in the hydraulic circuit above ambient
9 pressure. This ensures that a small leak would not
10 result in water being allowed into the hydraulic
11 circuit. An accumulator 54 provides hydraulic energy
12 to the valve circuit in the event of a power failure.
13 A dedicated interface or control unit 56 receives all
14 cable connections including power connections and
15 control signals such as position indicators, valve and
16 control actuation, and camera signals etc. The control
17 unit 52 is in turn connected to the valve pack 52 which
18 directs hydraulic signals to the valves accordingly. A
19 drawer assembly extends out from each side of the skid
20 frame 60 to access the sampling bottle 10 while
21 onshore. The drawer assembly comprises an outer drawer
22 64 which houses an inner drawer 63. The outer assembly
23 64 slides out from the skid and the inner assembly 63
24 slides out from the outer assembly 64 in a telescopic
25 manner. The sampling bottle 10 is mounted on the inner
26 drawer 63 and may be conveniently accessed. A similar
27 drawer assembly (not shown) is provided for the second
28 sample bottle 110. The gauge typically remains fixed
29 to the sample bottles 10, 110 when removed.
30
31 When the samples have been collected from the wellhead
32 the ROV 200 docks at the operating station and a slops

1 tank 41 is connected to the sampling apparatus 100 by
2 line 123 via a valve 26 and a valve 45 as shown in
3 Fig. 21. The slops tank 41 comprises a tank 42, a
4 pressure gauge 43, a temperature gauge 44 and three
5 valves 45, 46, 47. In practise the first sampling
6 bottle 10 is used to store production fluids that are
7 drawn initially from the collection port at the
8 wellhead, as the initial sample will generally be of
9 fluids that are lodged static in the wellhead rather
10 than an accurate reflection of the fluids flowing
11 through the wellhead. Therefore the fluids from the
12 first sampling bottle 10 will typically be expelled
13 into the slops tank 41.

14

15 The pressure 43 and temperature gauges 44 on the slops
16 tank 41 should be visible from manual control valve 26.
17 A blind flange 48 is provided for positive isolation
18 after the inlet piping 49 has been disconnected.
19 Typically the level of the liquid in the tank 42 is
20 measured using a portable, non-intrusive level
21 gauge (not shown).

22

23 The sampling apparatus 100 is typically completely
24 vented, dismantled and cleaned between offshore trips.
25 The sampling apparatus 100 is tested prior to each
26 mobilisation to check its integrity and to confirm
27 there has been no degradation of components, such as
28 steels, during storage. The first test is a
29 hydrostatic test. The pressure of the water during the
30 hydrotest will normally be up to 230 barg and
31 de-mineralised water is normally used.

32

1 In the hydrostatic test the water pump 25 is connected
2 to the connection means 30 (not as shown) and the valve
3 12 is opened. Water is pumped into the first sampling
4 bottle until the piston is pushed to approximately half
5 way along the bottle and the valve 12 is closed. The
6 equivalent operation is then performed for the second
7 sampling bottle 110. That is, the water pump 25 is
8 connected to the connection means 130 and the valve 112
9 is opened. Water is pumped into the second sampling
10 bottle 110 until the piston 116 is pushed to
11 approximately half way along the bottle and the valve
12 112 is closed. The male plugs 30, 130, 40, 140, 50 are
13 removed to make the system more sensitive to leaks.
14 The valves are then switched to the status as shown in
15 Fig. 1. That is valves 14, 114, 12, 112, 18, 118, 126
16 are closed off and the remaining valves 11, 111, 13,
17 113, 17, 117, 19, 119, 120, 20, 22 are opened.
18 De-mineralised water is pumped into the apparatus as
19 shown in Fig. 2. The pressure is increased in steps up
20 to the test pressure of 230 barg.
21
22 The water pump is then disconnected and the system left
23 for a period of 30 mins. The pressure is monitored and
24 any change indicates a leak.
25
26 Once the pressure test is complete valve 26 can be
27 opened to drain and depressurise the skid. Provided a
28 satisfactory hydrotest has been completed the gas test
29 can now be carried out.
30
31 The gas test equipment set-up is shown in Fig 2b. To
32 start the test the skid is depressurised and the valves

1 12, 18, 112 and 118 are opened to ensure there is no
2 trapped pressure. Hoses are attached to connection
3 points 30, 130. Water will be pushed out through
4 valves 12, 112 when the pistons are pushed to the back
5 of the bottles.

6

7 Valves 14, 114, 18, 118 and 26 are closed and valves
8 11, 12, 13, 17, 22, 19, 20, 113, 117, 119, 111, 120 and 112 are
9 open as shown in Fig. 2b. The system is then connected
10 to a compressed nitrogen supply via the male/female hot
11 stab connection 33, 34, before the skid 160 is
12 submerged in a water bath and the nitrogen supply
13 regulator is set to 125 barg. Hydraulic pressure is
14 applied to open the hot stab sleeve 35, and the system
15 is then purged with nitrogen. The pistons are checked
16 for movement to ensure that the bottles have been
17 purged. Water should be pushed out the back end of the
18 bottles through the connections at 12 and 112. It is
19 important that the pistons are against their stops at
20 the back of the sample bottle so that the piston seals
21 are subject to a differential pressure.

22

23 The hydraulic supply to the male hot stab is then
24 removed in order to close the sleeve 35, and the
25 nitrogen supply is then isolated and disconnected.

26

27 The submerged skid 160 is checked for about 30mins for
28 bubbles indicating leaks. If the piston seals are
29 leaking bubbles may be seen leaving the skid from
30 connections in the vents lines from 12 or 112.

31

1 With the skid 160 removed from the bath valve 26 is
2 opened and the system is vented to atmospheric
3 pressure.

4
5 Before offshore mobilisation the skid can be re-tested
6 in order to check the integrity of all connections.
7 The slops tank 41 is assembled as shown in Fig. 21.
8 Valves 46, 47 are closed and valve 45 is opened.

9
10 The slops tank 41 is then filled with nitrogen via the
11 valve 45 up to a pressure of 2.5barg. The outlet ports
12 from all valves are left clear so that leaks past the
13 valves can be detected, and the skid is allowed to
14 stabilise for a period of 10 mins. Valve 45 is closed
15 and the nitrogen supply is disconnected while pressure
16 is monitored for a period of 30 minutes and a soapy
17 solution is applied to all flange joints and valve body
18 joints to check for leaks.

19
20 If there is leakage it will most likely be past the
21 valves or from the flanged connection on the vessel.
22 The flanged connections may have to be re-assembled or
23 the valves refurbished/replaced.

24
25 After the test the valve on the slops tank 41 can be
26 released and the pressure in the tank allowed to drop
27 until it reaches 0.1 barg.

28
29 To transport the skid before operation the sample
30 bottles 10, 110 are filled with a water glycol mix
31 according to the following procedure with reference to

1 Fig. 3 after the tests for leaks are performed as
2 described already.

3
4 The sampling system is vented down to atmospheric
5 pressure. When the leak testing is complete valves 14,
6 114, 18, 118 and 26 are closed, and all other valves
7 should be open.

8
9 A water/glycol supply pump is connected to the
10 connection at 12 and fluid is pumped into the back 27
11 of the sampling bottle 10, checking that the piston 16
12 moves towards the front of the bottle.

13
14 When the piston 16 reaches the front of bottle 10
15 valves 12 and 20 are closed, and the water/glycol pump
16 supply line is moved to the connection at 112, so that
17 fluid is pumped into the back of bottle 110. When the
18 piston 116 reaches the front 128 of bottle 110 valve
19 112 is closed as are valves 120, 22 and 26 in sequence.

20
21 At this point the manual needle valves 15, 115 in the
22 vent lines from 14 and 114 should be at $\frac{1}{4}$ turn open.
23 Pressure caps are then inserted at the exit of valves
24 26, 12, 18, 112 & 118, and the tubing ends at the vent
25 lines from 14 and 114 are capped off. Valves 26, 12,
26 18, 112 & 118 are then locked in the closed position,
27 and at this point the bottle pistons 16, 116 should
28 both still be at the front end 28, 128 of the bottles.

29
30 The system is now in its transport condition (refer to
31 Fig. 4a). Typically the water/glycol mix will be

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1 present in the sampling bottles when the ROV 100 and
2 attached skid 160 dives.

3
4 Spare sample bottles are provided and require to have
5 the production fluid side flushed with de-mineralised
6 water. These bottles should be separately hydrotested
7 to 230 barg and nitrogen tested to 125 barg to test the
8 piston seals and valves.

9
10 The back end 27, 127 of each of the bottles 10, 110 is
11 filled with the water/glycol mix so that the piston 16,
12 116 is at the front 28, 128 of the bottle. All valves
13 on these bottles are left in the CLOSED position (refer
14 to Fig. 4b).

15
16 In use for sampling operations, the ROV 200 flies to
17 the wellhead and docks at a panel (not shown). The
18 docking probes 71, 72 are inserted and the ROV 200 is
19 stabilised. The male hot stab 33 on the mounting
20 bracket 65 is aligned with and inserted into the female
21 connection 34 on the wellhead. The grabber tool 63
22 then releases the hot stab tool 33 and the lower
23 carriage of the tool deployment unit is withdrawn.

24
25 Samples are then removed from the wellhead as follows:
26 The current inlet pressure to the manifold flowmeter is
27 checked and recorded with a central processing
28 facility. The pressure can typically be read from the
29 pressure transmitter at the inlet to the flowmeter or
30 from the transmitter within the flowmeter. The
31 operating pressure read at the manifold should not be
32 greater than 97 barg. However, as the accuracy of the

21

1 subsea manifold gauges cannot be guaranteed a sample
2 may still be taken even if the manifold gauge reading
3 is greater than 97 barg.

4

5 The panel valves should be configured as shown in Fig.
6 6a. Hydraulic pressure is applied to the male hot stab
7 in order to push back the sleeve 35. The sample
8 isolation valves 31, 32 on the panel are operated using
9 the low torque tools 61, 62. Sample Isolation Valve 32
10 is opened (Fig. 6b) to admit the sample into the
11 collecting device and then closed. Thus the pressure
12 between the two sample isolation valves 31, 32 will be
13 the flowmeter operating pressure as determined from
14 step 2 (Fig. 6c).

15

16 Sample Isolation Valve 31 is opened to expose the hot
17 stab connection to pressure whilst still providing
18 isolation between the flowmeter and the hot stab (Fig.
19 6d). Preferably the operator should observe that there
20 is no fluid leakage from the hot stab. If there is
21 fluid leakage then Sample Isolation Valve 31 is
22 preferably closed and the sampling operation must be
23 re-attempted after the hot stab connector is checked.
24 In this case the hot stab sleeve 35 is closed and
25 removed while the ROV 200 undocks from the panel and is
26 recovered the surface where the Sample Isolation Valve
27 32 is opened.

28

29 Preferably the XYZ tool position at the Sample
30 Isolation Valves 31, 32 is maintained. This enables
31 quick isolation of the line to be made should any
32 problems be encountered.

22

1
2 Valves 22 and 20 are then opened as shown on Fig. 7.
3 This will expose bottle 10 to the operating pressure.
4 Check that the pressure gauge on bottle 10 indicates
5 the pressure of the sampled fluid, and valve 14 is then
6 opened. This will allow the water/glycol mix to exit
7 from the back 27 of bottle 10 and production fluid into
8 the front 28 (as shown on Fig. 8). The time taken for
9 the piston to move from the front 28 to the back 27 of
10 the sample bottle is recorded. The typical time taken
11 for a 5 litre sample is set out in the table below.

12

13	Manifold Pressure	Time to take sample
14	(Barg)	(mins)
15	37	30
16	50	28
17	97	22
18	230	15
19		
20		

10230
1
2 The bottle 10 fills with fluid under pressure from the
3 manifold and the fill can be confirmed by the piston
4 position indicator. When the piston stops moving the
5 pressure shown on the bottle gauge should increase up
6 to the manifold pressure.

26

27 If after 5 minutes the bottle piston has not moved it
28 must be assumed that there is some form of blockage in
29 the line such as a build up of hydrates. In this case
30 the sampling operation may be abandoned. In this case
31 the valves 22, 120 and 31, 32 are closed, and the ROV

23

1 200 undocks from the panel and is recovered to the
2 surface.

3
4 In the event of satisfactory fill, the valves 20,14 are
5 closed when the piston moves to the back of the bottle.

6
7 Valve 120 is opened and the pressure gauge on the
8 bottle 110 is checked to indicate the pressure of the
9 sampled fluid.

10
11 Valve 114 is then opened and the time taken for the
12 piston to move from the front 128 to the back 127 of
13 the bottle is recorded. Typically the time to taken
14 for the second bottle 10 to fill will be similar to the
15 times given for the first sampling bottle 10.

16
17 As the sampling bottle 110 is filled with fluids from
18 the wellbore at its first end 128, the water/glycol mix
19 is expelled from its second end 127. A throttle (not
20 shown) may be provided to control the rate at which the
21 water/glycol is expelled and so control the rate the
22 sample fluids are introduced into the sample bottle
23 110. A more representative sample of the fluids in the
24 wellhead is typically recovered in this controlled
25 fashion.

26
27 When the bottle is full the piston rod 139 will be
28 fully extended and the pressure shown 129 on the bottle
29 gauge will increase to the manifold pressure.

30
31 Valves 120, 114, 31, 32 and 22 are closed in that
32 sequence and hydraulic pressure is removed from the

24

1 male hot stab 33 in order to close the sleeve 35. The
2 hot stab 33 is removed from the female connector 34.

3
4 The docking probes can be released and the ROV 200 may
5 undock the from panel. The sampling equipment should
6 now be configured as shown in Fig. 9.

7
8 The ROV 200 is then brought back to the rig or other
9 operating station where the sampled fluid is recovered.

10
11 The actual arrangement of equipment can vary according
12 to the ROV 200 and other factors. Gravity is sometimes
13 required to assist the flow of fluids from the sampling
14 skid to the slops tank and the arrangement of the
15 equipment on the vessel can optionally take account of
16 this. Typically the slops tank should be located on
17 the deck of the vessel such that the flexible vent line
18 from the safety relief valve can extend over the edge
19 of the vessel. The end of the flexible should
20 preferably be situated such that it is not adjacent to
21 any intakes, exhausts or ignition sources. The vent
22 line should typically be secured to the side of the
23 vessel and the area around the line roped off to
24 personnel. The weather conditions at the time of the
25 sampling operation should also be taken into account.
26 This may necessitate re-locating the vent hose end.

27
28 If possible the ROV 200 launch/recovery platform should
29 be located at a higher elevation than the top of the
30 slops tank 41. This is to allow the waste fluids from
31 the skid to flow into the slops tank 41.

32

1 The slops tank 41 should be positioned during transport
2 such that it is within reach of one of the vessel
3 cranes. This is so that, if necessary, the sampling
4 skid can be lifted above the slops tank 41. This may
5 be required to give the necessary height above the
6 slops tank 41 if this cannot be achieved from the ROV
7 200 launch/recovery station.

8
9 The slops tank 41 should be located sufficiently close
10 to the ROV 200 launch/recovery station such that the
11 hose used for venting operations can reach between the
12 connection points at 26 on the skid and the valve (not
13 shown) on the slops tank 41.

14
15 After recovery to the surface the bottle containing the
16 production sample is removed from the skid. The
17 replacement of sample bottles will generally be carried
18 out with the skid on the deck. To this end each
19 sampling bottle 10, 110 is mounted on a drawer assembly
20 63, 64 and can be conveniently accessed. It is
21 suggested that the connections to the ROV 200 are
22 maintained so that hydraulic power is available to
23 operate the actuated valves. However, if the ROV 200
24 is urgently required for other tasks then the skid can
25 be disconnected from the ROV 200 and the manual
26 overrides on the actuated valves used. This can be
27 achieved using a hydraulic hand pump via a manual
28 switching circuit on the skid or by a screw to maintain
29 the piston on the valves in a closed position, so that
30 individual valves can be physically closed. All
31 actuated valves will typically fail in the closed
32 position when the hydraulic supply is removed. The

1 hot-stab comprises a spring return mechanism which will
2 activate when the cylinder has been vented and so does
3 not require hydraulic power to in order to open it.

4
5 The pressure shown on the bottle gauges is checked. If
6 either bottle contains fluid at greater than 97 barg
7 then this is outwith normal operating conditions and
8 the bottles cannot be vented as detailed below. This
9 is due to the excessively low temperatures that would
10 be produced when venting fluids of this pressure to the
11 slops tank 41. These abnormal pressures are likely to
12 be as the result of a process upset and further
13 sampling should not be carried out until the cause of
14 this upset is determined. If the sampling operation is
15 to be continued then the two bottles containing the
16 high pressure production fluids will have to be removed
17 and new bottles inserted as will be described later.

18
19 As bottle 10 will be used for each sampling it must be
20 vented and re-filled with water/glycol between each
21 run. Venting the skid makes use of the slops tank 41.
22 The following checks should be made each time the slops
23 tank 41 is used:-

24
25 Valves 45, 46 and 47 should be closed. This is
26 particularly important the first time the tank is used
27 offshore as it will have been filled and purged with
28 nitrogen before shipping. If valves 46 or 47 are found
29 to be open then the slops tank 41 must be re-purged
30 before use. Pressure in the tank should not be greater
31 than 2.0 barg prior to each filling operation.

1 Temperature of the tank should be in the range -6°C to
2 +50°C.

3
4 The tank level indication on the ultrasonic level
5 detector is then checked. Level of the fluid in the
6 tank should be 200mm or less. The vent piping from the
7 pressure safety valve should be attached and discharged
8 to a safe area. The end of the vent piping should be
9 free from blockages. The hose used to connect to the
10 sampling skid should be in good condition and the end
11 connection should be checked for debris.

12
13 In order for the production fluids to be drained from
14 the skid should typically be at a higher elevation than
15 the slops tank 41. If the ROV 200 launch platform is
16 located above the top of the slops tank 41 level then

17 the skid should be kept on the ROV 200 and the
18 hydraulic supply can be used to actuate the valves.
19 Ideally the operator at the ROV 200 location should be
20 able to view the pressure and the temperature gauges on
21 the slops tank 41 while valve 26 on the skid is being
22 operated. If this is not possible the operator at the
23 skid should preferably have a clear view to the slops
24 tank 41 and a second operator should be stationed at
25 the slops tank 41 to monitor the gauges.

26
27 If the ROV 200 launch/recovery station is not at a
28 higher elevation than the top of the slops tank 41 then
29 the skid may have to be removed from the ROV 200 and
30 lifted above the slops tank 41. The following steps
31 must be taken:-

32

1. Close all valves on the skid.
2. Vent down all the hydraulic connections to the skid (actuated valves and hot stab).
3. Disconnect all hydraulic and electrical lines from the ROV 200.
4. Remove the skid from the ROV 200.
5. The skid can now be moved by its lifting points to a location at a higher elevation than the slops tank 41.

10
11 The manual overrides on the hydraulic valves will now
12 have to be used to operate them. The operator should
13 be able to view the pressure 43 and temperature 44
14 gauges on the tank while valve 26 is being operated.
15 If the ROV 200 launch/recovery station is at a higher
16 elevation then these steps are not necessary.

17 Regardless of the position of the ROV 200
18 launch/recovery station, the following steps should be
19 taken.

20
21 Valves 111, 113, 117 and 119 should be closed and
22 valves 11, 13, 17 and 19 should be opened.

23
24 Valve 26 should be closed, and any pressure released
25 from behind the plug at 26 before it is removed. The
26 plug 50 is then backed off and the cap is depressed to
27 vent any trapped pressure. Once the plug 50 is removed
28 the hose is connected from the connection at valve 26
29 to the slops tank 41. Valve 45 on the slops tank 41 is
30 then opened, as is valve 26 (slowly) until fluid is
31 heard to escape through the valve to the slops tank 41
32 (the valve will have to be unlocked first). The valve

1 will reach extremely low temperatures while the fluid
2 vents through it. The pressure and temperature in the
3 slops tank 41 should be monitored at all times when 26
4 is open. The slops tank 41 pressure should be kept
5 below 2.5 barg. If the temperature falls below -25°C
6 then valve 26 should be closed, and the temperature
7 allowed to return to above -25°C before valve 26 is
8 opened again.

9

10 Valve 22 is opened, then 120, then 20; this will vent
11 the contents of bottle 10 to the slops tank 41. The
12 system will then be configured as shown in Fig. 10.
13 The pressure and temperature in the slops tank 41 is
14 then monitored recorded and maintained within limits
15 stated above.

16

17 Valve 14 is opened and the water/glycol supply pump is
18 connected to the connection point at 30. Valves 22 and
19 120 are then closed.

20

21 Valve 12 is then opened and water/glycol is pumped into
22 the back of bottle 10, checking that the piston 16
23 moves towards the front of the bottle 28. Production
24 fluid will be expelled through the connection at valve
25 26 into the slops tank 41 as shown in Fig. 11.

26

27 When the piston 16 reaches the front of bottle 10 valve
28 12 is closed. Valves 26 on the sampling skid and 45 on
29 the slops tank 41 are then closed.

30

30

1 At this point, the bottle 10 has been vented but the
2 section of pipework between valves 119 and 114,
3 including bottle 110, is still at pressure.

4
5 The bottle 110 should now be removed. Before bottle
6 110 can be removed the pressure either side of the
7 bottle must be vented, by closing valves 113 and 117,
8 backing off the plugs 130 and 140 and then depressing
9 the cap to release any trapped pressure before removing
10 the plugs. Valve 120 is closed, and the slops tank 41
11 hose is connected to the connection point 140.

12
13 Valves 45, 119 and 118 are opened sequentially to vent
14 the section of pipe between valves 117 and 20. There
15 should only be a small release of fluid from this small
16 section of pipe. If there is continual fluid release
17 and the pressure in the bottle falls then this
18 indicates valve 117 is passing. Valves 118 and 119
19 should in that case be closed, and the bottle can only
20 be removed if it is first completely vented to the
21 slops tank 41.

22
23 Valves 45, 118 and 119 are closed sequentially, and the
24 hose to the slops tank 41 is disconnected from valve
25 118.

26
27 The fluid at the back end of bottle 110 will be at the
28 hydrostatic water head pressure when the sample was
29 taken (around 10 barg for 100m depth). This pressure
30 must be vented before the bottle can be removed.

31

31

31

1 The slops tank 41 hose is connected to the connection
2 130, and the valves 45 and 112 are opened. The bottle
3 is still isolated by valve 113. If the pressure in the
4 bottle falls when valve 112 is opened then this
5 indicates both the bottle piston seals and valve 113
6 are passing. In this case the bottle must be
7 completely vented to the slops tank 41 before it can be
8 removed. This should be done through valves 117 and
9 118.

10

11 Valves 111 and 114 are opened, and valve 45 on the
12 slops tank 41 is closed before the hose 51 to the slops
13 tank 41 is disconnected. Valves 111, 112, 118 and 119
14 are closed (Valves 113 and 117 should already be
15 closed).

16

17 Valves 120 and 26 are then opened to ensure both the
18 points where the bottle connects to the skid are open
19 to atmospheric pressure. Bottle 110 still contains
20 production fluids at pressure and so should be handled
21 with care. Bottle 110 is disconnected.

22

23 A new bottle to be inserted should be pre-filled with
24 the water glycol mix at the back of the sample bottle.
25 The double block and bleed valves either side of the
26 bottle should be closed. The piston should be at the
27 front of the bottle and the pressure gauge should read
28 zero. The new sampling bottle should then be fitted to
29 the skid, checking that valve 119 connects to 120 and
30 111 connects to 114.

31

32 The pipework between the hot stab and the sampling
33 bottles will have to be flushed through to prevent

32

32

1 contamination between samples. De-mineralised water is
2 preferably used for the flushing operation in order to
3 avoid contamination of samples.

4

5 The skid valves should be configured as below:-

6

	Closed Valves	Open Valves
9	11	22
10	12	120
11	13	20
12	18	26
13	111	14
14	112	114
15	113	

16

17 There are three legs of pipework on the skid that must
18 be flushed through. The hot stab and check valve must
19 be disconnected and flushed in the flow direction due
20 to the presence of the check valve. Thus there are
21 four sections to be flushed; labelled A, B, C and D on
22 Fig. 14.

23

24 The de-mineralised water pump is connected to the
25 connection point 140 as shown in Fig. 14, and a hose
26 from the connection at valve 26 is connected to a
27 suitable receptacle. Valves 26 and 120 are opened and
28 the system should now be configured as shown in Fig.
29 14. De-mineralised water is then pumped through the
30 pipework, and fluid will exit from the hose at 26 to be
31 collected in the receptacle. Pumping is continued
32 until the fluid exiting 26 is clean, at which point

33

1 valve 26 is closed, valve 20 is opened, and the hose is
2 moved from 26 to 40. Valve 18 is then opened and de-
3 mineralised water is pumped through the pipework, with
4 fluid draining from 18 and pumping continuing until the
5 fluid exiting is clean. At that point, valves 18 and
6 20 are closed and valve 22 is opened, the hot stab and
7 check valve are disconnected from the rest of the skid
8 at the QC coupling.

9

10 The hose is transferred from 30 to the QC coupling, and
11 de-mineralised water is pumped through the pipework,
12 draining through the hose at 22, until clean, whereupon
13 the water pump is disconnected from the skid, the hot
14 stab is inserted into the dummy female receptacle, the
15 water pump is connected to the connection on the
16 female stab 34, the hot stab sleeve 35 is opened by
17 hydraulic pressure and de-mineralised water is pumped
18 through the hot stab and check valve, until clean.

19

20 The water pump is then disconnected from the female
21 stab 34, and valves 22 and 26 are closed.

22

23 The skid pipework is then purged with nitrogen prior to
24 each sampling run. This will be done to remove air
25 from the pipework prior to the introduction of
26 hydrocarbons.

27

28 The nitrogen supply is connected to the connection
29 point 140 as shown in Fig. 15. Valves 26 and 120 are
30 opened and the system should now be configured as shown
31 in Fig. 15.

32

34

34

1 The nitrogen supply is opened and the system is purged
2 through for a few seconds. Fluids will exit from the
3 connection at 26.

4

5 Valve 26 is then closed, and valves 20 and 18 are
6 opened. After a further nitrogen purge for a few
7 seconds fluids will exit from the connection at 18.

8

9 Valves 18 and 20 are closed, and valve 22 is opened.
10

11 After a further nitrogen purge, fluids will exit from
12 the end of the hose where the check valve and stab are
13 normally attached.

14

15 Valves 22 and 118 are closed and the nitrogen supply is
16 disconnected from the skid and connected to the
17 connection on the female stab 34.

18

19 The hot stab sleeve 35 is opened by hydraulic pressure,
20 purged with nitrogen for a few seconds and closed
21 before the check valve and stab are re-connected to the
22 skid pipework.

23

24 Hydraulic pressure is then applied to open the hot stab
25 sleeve 35, and checking that valves 18, 118 and 26 are
26 closed, valves 22, 120 and 20 are opened. The system
27 should be configured as shown in Fig. 16.

28

29 A nitrogen purge is generally conducted in two steps to
30 achieve a nitrogen purity of 99.9% of volume in the
31 skid pipework. Typically the piping is filled with

35

35

1 nitrogen to a pressure of 15 barg, and the nitrogen
2 supply is isolated.

3

4 Valve 26 is opened to vent the nitrogen, and then
5 closed.

6

7 The nitrogen supply is then opened and nitrogen fills
8 the piping to a pressure of 15 barg, after which the
9 nitrogen supply is isolated and the pipes are vented by
10 opening and closing valve 26.

11

12 As the connections between bottle 110 and the rest of
13 the pipework have been broken they must be re-tested
14 before another sample can be taken as follows: the
15 nitrogen supply is connected to the connection point at
16 valve 118 and the nitrogen supply regulator is set to
17 125 barg. At this point the bottle piston 116 should
18 be at the front 128 of bottle 110 and the bottle and
19 piping behind the piston 116 should be filled with the
20 water/glycol mix.

21

22 The skid valves should be configured as follows and as
23 shown in Fig. 17.

24

25	Closed Valves	Open Valves
26		
27	114	111
28	14	113
29	11	117
30	12	118
31	13	119
32	18	17

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1	112	19
2	22	
3	120	
4	20	
5	26	
6		

7 The above configuration will allow the piping between
8 valve 120 and the sampling bottle piston 116 to be
9 filled with nitrogen. The pressure in the pipework is
10 shown on the bottle pressure gauge. As the piston 116
11 is free to move, the water/glycol mix at the back of
12 the bottle will also be pressurised from the bottle
13 piston 116 through to valve 114. Thus both of the
14 points where the bottle is connected into the skid will
15 be tested. The bottle piston seal need not be tested,
16 as this will have been done onshore. Only a small
17 volume of nitrogen will be required to test the piping.
18 Thus the pressure in the piping will rise quickly when
19 the nitrogen supply is opened.

20
21 Soapy water is applied around the bottle connection
22 point adjacent to valve 20 to detect leaks. The
23 connection at the rear of the bottle should be dried.

24
25 The nitrogen pressure is gradually increased to a
26 pressure of 125 barg. The bottle piston 116 should not
27 move a significant amount during the test. If the
28 piston continues to move during pressurising then this
29 indicates a leak from the piping at the back end of the
30 bottle.

31

1 The nitrogen supply is closed by valve 118 and
2 disconnected, and the system is left pressurised for 30
3 minutes. Assuming no leaks valve 118 is opened to vent
4 off the nitrogen.

5

6 Once all sampling operations are complete the sampling
7 skid can be disconnected from the ROV 200. The skid
8 itself should not contain any fluids at pressure. The
9 only fluids at pressure will be within the sample
10 bottles.

11

12 The hydraulic supply lines to the sampling skid valves
13 are vented to atmospheric pressure, disconnected and
14 stored in the transportation case.

15

16 All electrical supply and control cables are
17 disconnected between the ROV 200 and the skid, any
18 hydraulic or electrical ports on the skid are capped to
19 prevent debris ingress. All valves are closed and
20 pressure caps are fitted on the outlets of valves 26,
21 12, 18, 112, 118. The flexible pipe from the safety
22 relief valve on the slops tank 41 should be checked for
23 security and left in place until the slops tank 41 is
24 demobilised from the vessel.

25

26 Before storage the valves 46 and 47 should be closed
27 and valve opened. The outlet ports from all valves
28 should be left clear so that leaks past the valves can
29 be detected. A final leak test is then carried out by
30 filling the tank with nitrogen through the connection
31 point at valve 45 to a test pressure of 2.5 barg for 10
32 minutes, after which the valve 45 is closed and the

38

38

1 nitrogen supply is disconnected. The pressure and
2 temperature are monitored over a period of 30 minutes,
3 and a soapy solution is applied to all flange joints
4 and valve body joints to check for leaks. If there is
5 leakage it will most likely be past the valves or from
6 the flanged connection on the vessel. The flanged
7 connections may have to be re-assembled or the valves
8 refurbished/replaced.

9

10 The nitrogen can be vented by opening valve 46. A
11 slight positive pressure of 0.1 barg is preferably
12 maintained within the vessel.

13

14 Modifications and improvements can be incorporated
15 without departing from the scope of the invention.

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